Configurations of activity : from the coupling of individual actions to the emergence of collective activity

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Configurations of activity: From the coupling of individual actions to the emergence of collective activity. A study of mathematics teaching situation in primary school.

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Abstract

This paper presents and uses the notion of configuration of activity, which extends the Norbert Elias's original concept of social configuration (1966) based on the study and analysis of individual and collective activity. Although this concept embraces all types of social activities, in the present study we used it to describe and analyze various classroom activities during a primary school mathematics lesson. Individual action is described as being meaningful to the agent, according to semiological theory of course-of-action (Theureau, 2003).

The configuration of activity in the classroom is described as a collective activity with a global form embedded in a culture and emerging from the dynamics of points of articulation between individual actions. It presents the main characteristics of autonomous systems: (a) the emergence of an order, (b) the individuation of a form, (c) the existence of a unit with borders specified by the process of self-reproduction, and (d) the system sensibility to perturbation by outside events.

Using the concept of the classroom configuration of activity, this study allows for new insights in the emergence of a teacher-pupils collaborative activity in the classroom.

Key words: activity, collective, emergence, classroom, mathematics, teaching

In the 6th grade classroom, pupils' desks are arranged to form four workgroups of four pupils each. The pupils are reading a duplicated text of a math problem that they have to solve. As the teacher moves from group to group she asks questions to make sure that the pupils understand the task. The pupils are involved in various activities: they mark up their problem sheets with highlighters, use their electronic calculators, answer questions, move around the classroom and talk to each other. The teacher monitors these activities observing group dynamics, confirms correct answers, helping some pupils and encouraging others, and confirming the correct answers. Although at first glance all these activities seem to be chaotic and spontaneous, a closer look will reveal a certain level of organization: the interaction between individuals forms a recognizable structure. These complex and dynamic forms of interaction have been termed "configurations of activity" (Durand, Saury & Sève, 2006), and their emergence in the classroom has become a focus of educational research (Durand, 2005).

This paper presents and uses a theoretical and methodological approach for studying these configurations of activity through the description and analysis of a classroom situation during a primary school mathematics lesson. We proceed in three steps: first, we introduce (a) the approach of "methodological situationism", the three presuppositions it is based on, and the notion of the intrinsic dynamics of activity. We then illustrate the concept of the configuration of activity through the case study of a typical classroom teaching situation. Finally, we provide a detailed examination of this concept and an assessment of its relevance for educational activity description.

“Methodological situationism”

Our approach is grounded in the following theories: (a) situated action (or cognition) theories (Kirshner & Whitson, 1997), (b) activity theory (e.g. Engeström, Miettinen & Punamäki, 1999), and (c) cognitive phenomenology (Varela, Thompson & Rosch, 1999). It focuses on the articulation of social and individual dimensions of activity, making a special emphasis on classroom activity. The approach differs from the current research trends based on the assumption that collective activity depends on individual actions and, for example, evolves from individual representations. From this perspective, representations determine or prescribe collective activity. Our approach also differs from those ones that assume the opposite, namely, that individual action depend on collective activity. This assumption implies that the organization determines or prescribes individual action.

Our approach is based on three presuppositions: (a) self-organization of individual action, (b) lack of opposition between the individual and social dimensions of activity, and (c) fundamental semiosis basis of activity. The first presupposition is that individual action emerge from the “activity – situation” coupling (Varela, 1979). This coupling embraces the fundamental property of living and social systems, regardless of their level of organization or complexity: living systems develop and maintain their structure through the exchange with the environment in a process of permanent self-organization (Fuchs, 2006; Luhmann, 1995). The changing forms of this coupling result from the dynamics of life and from the viability of the system to its environment. In other words, the organization of individual action is considered to be essentially autonomous, although extrinsic constraints on this coupling do occur (Theureau, 2002, 2003). The organization of action and the meaning attributed to them by their agents should be considered by the researchers thus need to be taken into account by modalities other than the outside “causes” of coupling (Andersen, Emmeche, Finnemann & Christiansen, 2000). From the same perspective, the organization and meaning of collective activity proceed from the articulation of individual action in accordance with the emerging dynamics that is different from but analogous to the dynamics that characterizes individual action. When individual situations allow it, global cooperation emerges spontaneously, regardless of precise rules or a central authority. Phenomena of this type have been described as “latent organizations” by Starkey, Barnatt & Tempest (2000), or as “intelligent crowds” by Rafael (2003), in the context of new technology use.

The second presupposition is that the individual and the social are not two distinct entities or ontological realities. Individuals form groups: although separate as ontological entities, they are united by a common structure that distinguishes them from an “exterior” in a dynamic and labile manner. The individual and the social are thus intrinsically connected. Individuals attribute a meaning to the collective activity in which they are involved insofar as the latter allows for the accomplishment of individual action. According to Elias (1966, 1978, 1991), the concept of social configuration can be used to describe and explain the interdependency of relationships, the tensions between individual actions, and the relatively stable forms of this system of interdependence. Social configurations are constructed by individual agents as they interact collectively in a certain situation, yet these configurations are independent of both individual intentions and awareness. They are *gestalts* that stand out from the background. They are limited in space and time and can be described as emerging processes of distribution and dynamic balancing of tensions. Social configurations are “concrete” in that they are “no more and no less real than the individuals who make them up” (Elias, 1966, p.397). They are global forms with ever-changing dynamics produced by interaction. They offer a potential for action, imposing balance and thus facilitating the achievement of goals. They present opportunities both for addressing individual preoccupations and for achieving a social balance often based on individual goals that do not necessarily converge.

The last presupposition is that configurations of activity emerge from the meanings that individuals attribute to their action and environment, yet these configurations may never become meaningful in themselves. Each agent’s action is based on semiosis; that is, on processes of construction or attribution of meaning in direct and essential connection with the organization of their action (Theureau, 2002; Chaliès, Ria, Trohel & Durand, 2004). Agents interact only with issues that are meaningful to them. In other words, agents are fundamentally and permanently engaged in the construction and reconstruction of an “*umwelt*” (Uexküll, 1992), i.e. a meaningful situation. Our study adopts a situated action approach in which the situation is defined as part of the objective environment whose meaning is constructed by the agent We insist that activity must be studied as a whole, that not only does the agent's action carry the imprint of the environment in which it unfolds, but also that the agent "has a situation" in Dewey's sense (1938/1963). This means that the agent has an irreducible point of view at the environment that generates meaning, and that cognition is mainly culturally situated, i.e. that the culture offers possible actions which are or are not actualised in context.

Classroom activity analysis

The course of action approach is part of a wider research program aimed at analyzing teachers' and pupils' classroom activity in various subject matter contexts at different curriculum levels. These studies focus on the teaching process (Durand, 1999; Durand, Saury & Veyrunes, 2005), classroom preoccupations and emotions of the beginning teachers (Bertone, Méard, Ria, Euzet & Durand, 2003; Ria, Sève, Theureau, Saury & Durand, 2003), the interaction between beginning and cooperative teachers (Chaliès, Ria, Trohel & Durand, 2004), teacher-pupils classroom conflicts (Bertone, Meard, Flavier, Euzet & Durand, 2002; Flavier, Bertone, Hauw & Durand, 2002), and the distance learning process (Leblanc, Durand, Saury & Theureau, 2001). Although all these studies provide new insights into the teaching and learning process and interaction, none of them examine the collective activity in the classroom. This is the scope of the present study...

To understand configurations of activity, one must examine the construction processes of activity-situation coupling, focusing on the meaning attributed to the environment within which agents act. This approach emphasizes the importance of the agent's point of view. In the classroom, for example, an individual agent's action partly depends on the individual action of other agents: this interdependence can be termed "individual activity – situation" coupling. This coupling is at the origin of the configuration of activity within which it unfolds, and yet is also made possible by it. Individual actions of agents are meaningful to each of them insomuch as they can articulate these actions among themselves and in accordance with the configuration of collective activity that emerges from these actions. However, each agent only considers configuration issues that are meaningful to him/her, but might not have the same meaning to another agent. This means that: (a) agents do not have a global and thorough understanding of the configuration of activity in which they are involved, and (b) the configuration needs to be analyzed by the researcher from a dual point of view: (a) a point of view of an external observer, which can be metaphorically termed the "point of view of the configuration"; and (b) a point of view of an agent, termed the "point of view of the actor", or the internal point of view. The researcher uses agents' verbalisation to interpret their experience during action. These methods of observation, coupled with self-confrontation interviews where agents are invited to comment on their own action while being video recorded, give the researcher an opportunity to coordinate the two points of view on action.

In this study, we refer to collective configuration of activity and *not* to configuration of collective activities. Unlike both individualistic and collectivistic approaches, this approach focuses on the emerging activity-situation coupling and has been termed "methodological situationism" (Theureau, 2002, 2003).

Our approach to classroom activity has been influenced by (a) Doyle's concept of classroom ecology (1986) that describes the classroom organization and management as a structured, singular, complex and interactive process, resulting from a set of processes and dispositions carried out by the teacher to assure a supportive classroom environment for pupils; (b) the interactionist approach that maintains the idea of "social construction of the reality" (Schütz, 1970) and considers the way that actor's interpret the classroom reality (Allen, 1986; Mehan, 1979); and (c) the distributed cognition approach that emphasizes the collective and cultural aspects of action and interaction between actors and between them and the outer world, placing them within network sustaining trajectories of participation in which cognition is socially distributed (Barab & Kirshner, 2001; Roth, 2001; Salomon, 1993) and supported by objects (Saxe, 2002).

Our approach is aimed at explaining collective activity in an educational setting by: (a) giving similar importance to individual action and collective activity; (b) adopting the actors' point of view; (c) taking into account the meaning they construct about their action; (d) adopting a qualitative methodology that provides a detailed description of global interactions in the classroom (and not only dyadic interactions); (e) focusing on phenomenon that are not pre-defined.

The intrinsic dynamics of action

We describe individual action and its articulation within the semiological theory of the course of action (Theureau, 2003). This theory models the level of individual action that is meaningful to the agent, i.e., the level that can be shown, told and commented on by him or her. Course-of-action theory presupposes that this level of organization is relatively autonomous in relation to other levels of analysis, but that it represents the agent's global action (Theureau, 2003).

The individual course-of-action consists of a flux of action which includes three main components: (a) preoccupations, (b) perceived meaningful aspects of the situation and (c) cognitive elements of generality (i.e., knowledge). The preoccupations correspond to all the possibilities of action, relatively indeterminable and limited in time, that are open to the agent in a given situation (i.e. "*Help pupils*"). They emerge from the possibilities linked to the agent's past. These preoccupations are blurred, indeterminate (Ex.: "*Help the pupils establish links between important numbers*" or "*Get the pupils back on task*"). At the same time, these preoccupations are specified in the action by the aspects of the situation which the agent perceives and which are meaningful to him (Ex.: "*The pupils haven't noticed the important indications*" and "*The pupils are becoming discouraged*"). This refers to the knowledge present in cognition in the unfolding situation but arising from past courses-of-action (Ex.: "*Highlighting helps the pupils to find the key information'* and "*Finding the key information helps to solve a problem*").

Table 1: Example of action unit components

<u>Actions and verbalizations in the classroom and self-confrontation interviews</u>

[A pupil makes a sigh of discouragement]

<u>Teacher (in the classroom)</u>: Give me a highlighter!

<u>Teacher</u> (during a self-confrontation interview): OK, let's do it again! So, here I'm going to highlight, because they haven't done it: This annoys me, and I want them to see it! I want them to see that it's over here — it's over here that it counts... There you go, here's one, and then the other!

Preoccupations: Help the pupils

- Help the pupils to establish links between important numbers

– Get the pupils back on task

Perceived meaningful aspects of the situation

– The pupils haven't noticed the important information

– The pupils are becoming discouraged

Elements of Generality (Knowledge)

– Finding key information helps to solve a problem

– Highlighting helps the pupils to find key information

Collective activity results from the synchronic and diachronic coupling of several agents' courses-of-action. This coupling results from multiple points of articulation between two courses-of-action, that is, local relations of interdependence (mutual dependence). Points of articulation occur between two (or more) courses-of-action when one or more components of one agent's course-of-action correspond to one or more components of the other agent's course-of-action. This articulation is produced by the convergence or divergence of preoccupations and actions, like, for example, in a situation of supervision in a teacher education program (Chaliès, Ria, Bertone, Trohel & Durand, 2004).

Our research approach extends beyond the interaction between two agents, focusing on the collective activity of several agents. The configuration of activity in its changing dynamics is studied based on collective articulation of preoccupations and actions of the participating agents at a given moment.

A case of collectively solving a mathematics problem

This case study is an excerpt from a considerably more extensive research program (Durand, Saury & Veyrunes, 2005). We have chosen it because it perfectly illustrates some typical situations observed during mathematics lessons.

The teacher conducted a mathematics lesson in Year 6 class (the highest level of primary school in France) in a small rural school with only three classes. There were eighteen 11-year-olds in the classroom. Six lessons were video-recorded and analyzed based on the notion of proportionality. One of these lessons was selected as representative of a configuration of math problem solving activity. Two types of data were collected and analyzed: (a) data of pupils' and teachers actions' observation: recordings of classroom actions with a video camera; (b) data from self-confrontation interviews held immediately after the lesson. After the teacher and the researcher had closely examined the video recording, the teacher was invited to comment on her actions, i.e. to explain what she was doing, what she was thinking about, what she perceived and what she felt at a particular moment. The researcher's role was to identify specific events and to encourage the teacher to comment on her own action while avoiding *a posteriori* interpretations, generalizations, or explanations that were not directly connected with these actions.

Data processing was carried out in five stages:

Stage 1: Chronological presentation of collected data. For this purpose, a three-column table was created. Column 1 comprises the traces of the activity in the classroom: *verbatim* transcription of participants' verbalizations, pupils' work, and schemas made by the teacher. Column 2 comprises the video file of pupils' and teachers' behaviours and interactions along with their full description. Column 3 comprises the *verbatim* transcription of self-confrontation interviews corresponding to the teacher-related data in Column 1.

Stage 2: Identification of components. Detailed examination of participants' behaviours and communications in the classroom and during the self-confrontation interview. Preoccupations were identified and categorized. Based on the responses to the following questions: What are the agent's preoccupations at the time under study? Pupils' preoccupations were identified by inferences performed during self-confrontation interviews and based on pupils' behaviour and verbalizations, on researchers' experience of the classroom (all of them have been teachers), and on their expertise in the course-of-action theory. Inferences made by the researchers in a blind procedure achieved a 92%-level of agreement; disagreements were resolved through follow-up discussions between the researchers". Perceived meaningful aspects of the situation were identified and categorized using the responses to the following question: what perceived or remembered elements of the situation were meaningful to the agent at a moment of study?

Stage 3: Linking the teacher's and pupils preoccupations with those of the students by noting the convergence and divergence between them.

Stage 4: Study of the points of articulation in the configuration of activity. The points of articulation were determined based on what elements of the situation are meaningful to agents in the situation: if a certain element of the situation (in this case, for example, the math problem) is meaningful to two or more agents, it is considered to be an articulation point in the configuration of activity.

Stage 5: Description of the dynamics of the configuration of activity, i.e., the tensions and the balance resulting from the coupling of courses-of-action in the classroom.

During a follow-up discussion between two researchers, they resolved any existing disagreement about the decomposition of courses-of-action, the component categorization, and the convergence/divergence of preoccupations, achieving 97% of agreement. After consulting with the third researcher, they achieved a full agreement (100%).

During the lesson, the pupils were asked to solve a proportion problem using a scale (see Figure 1).

YEAR 6 PROBLEM SITUATION (1)

A boy wants to build a model car.

He can choose between two sizes:

– a 1:45 scale model (9 cm long and 3.2 cm wide)

– a 1:20 scale model (22 cm long and 7 cm wide)

He wants to build the one that is really bigger, the one that would be bigger if he saw them both in the street.

Which one should he choose?

Tips:

1) – Think about the scales presented in the text

(Relationships between units) cm-cm

2) – Think about the tables that show the real car-model relationship

Figure 1. Facsimile of the problem given to the pupils

Individual actions during math problem-solving

Teachers' individual actions. The class was divided into groups of four or five pupils in four work areas; in each area, pupils' desks were put together. Once the problem sheets were handed out and the problem was read out loud, the pupils started searching for the solution. The first responses given by Gerald, Gregory, Justine, and Charlotte[1] were invalidated by the teacher. In the 25th minute, Gerald suggested a solution that involved dividing one scale by another one. The teacher invalidated this suggestion with a simple "no".

In the 29th minute, the teacher confirmed Justine's response pointing out that she had spotted an important piece of information, that is, that the two models were of different size. The teacher's preoccupations were: (a) *to confirm Justine's response*, (b) to *stimulate Justine's involvement in the given task so that she would continue working,* and (c) *to prevent the pupils in Charlotte's group from confusing the numerical data of the two models*.

The teacher's preoccupation with helping the pupils to understand the reduction ratio was expressed by a reference to "their life outside school". The teacher thus commented on her own action: "S*o, now I am trying to help Justine because I know she goes walking with her uncle...* […]. *So I say: OK, who has ever run a kilometre? And I am waiting for Justine to say...: I do, every Saturday I go walking with my uncle. We take the model diagram, we look at it, and... When you put your foot on the diagram, you can see that it goes over the edge?"* The teacher's preoccupations at that moment were: (a) *to help Justine by evoking a meaningful experience outside school,* (b) *to help Justine understand the reduced scale presented on the diagram,* and (c) *to keep Justine focused on the prescribed task.*

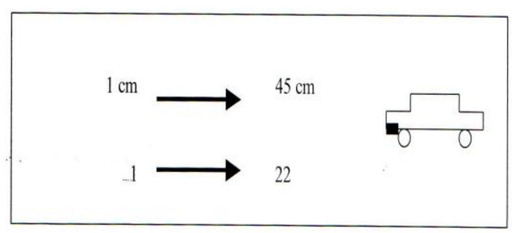
In the 38th minute, Justine came up with a new suggestion. Although the girl had figured out the relationship between the width of the first model and its scale, she had divided instead of multiplying. The teacher asked her to encircle a different answer on a worksheet than the 3.2 that Justine was focused on. She wanted the pupils to compare the

[1] This group of pupils is thereafter called Charlotte's group.

length and width of the cars in relation to their respective scales by multiplying the dimensions of each model by its scale, and then to compare the results. For Model one: 9 x 45 = 405 and 3.2 x 45 = 144 and for model two: 22 x 20 = 440 and 7 x 20 = 140. Her preoccupation was: *to invalidate incorrect suggestions*.

Because two of the four groups could not find the right solution, the teacher decided to help them. In the 42nd minute, she went to the blackboard and gave additional explanations. She focused her attention on the pupils who experienced difficulties in the two groups. Using drawing, she illustrated the scale ratio, pointing out that 1 cm on the scale corresponds to 20 cm or 45 cm (depending on the scale) of a real car. Her preoccupations were: (a) *to help the pupils find and perform the multiplications to be carried out,* (b) *to help the pupils understand the problem using an example from a real-life situation,* and (c) *to keep the pupils involved in a given task.* The teacher Justine's answer with a big smile and an exclamation of satisfaction". Her preoccupation was to *validate on Justine's suggestion.*

Table 2. Excerpt from classroom verbalizations (Minute 42)

Classroom verbalizations	**Video and Behaviours description**
<u>Teacher</u>: …1 cm on the model… <u>Justine</u>: I know! <u>Teacher</u>: Means, in real life, 45 cm… <u>Justine</u>: … 1 cm on the model is just 1 cm, but on a normal big car that will be 40 cm … uh, 45 cm. <u>Teacher</u>: Yes, that's right! So, think about this: if you have 2 cm? <u>Pupil</u>: You have to multiply! <u>Justine</u>: 45 multiplied by 2! <u>Teacher</u>: Ahhhh! <u>Pupil</u>: 45 multiplied by 22! <u>Teacher</u>: Ahhhh!	 Facsimile of the schema drawn on the blackboard by the teacher (Minute 42)

In the 54th minute of the lesson, having realized that the pupils were not on the right track, the teacher returned to Charlotte' group and repeated her explanation. During the self-confrontation interview, the teacher said that the period of time between the 54th and 58th minutes was quite difficult. She reviewed and marked up the text of the problem in order to help the pupils identify the important information using a highlighter.

Table 3. Classroom and self-confrontation verbalizations (Minute 54)

Classroom verbalizations	**Video and description**	**Behaviours**	**Self-confrontation verbalizations**

Teacher: Give me a highlighter!

Do we agree that this and this are the measurements of the little car?

Gerald: Yes!

Justine: Yes!

Teacher: And that this and this are the measurements of the other little car? OK?

Gerald (in a whisper): I see!

Charlotte (in a loud voice): I see!

Teacher holds out her right hand Justine gives her a highlighter

Charlotte in-knee, leans over the document and watches how the teacher is highlighting the text.

Gerald also leans forward and does the same.

At this time, Gerald leans over his copybook and sets to write.

Charlotte sits up clapping her hands

Teacher: So, let's have another look! So, I'm going to highlight, because it hasn't been done: It's annoying me, and I want them to see!

Researcher: What are you highlighting, the numbers?

Teacher: The numbers which are... boom! That one with that one, and this one with this one, that's all.

Researcher: Are you highlighting the four numbers on the photocopy?

Teacher: And I want them to see that it's over here, over here, and that makes, there... There is one and then there is another one!

Researcher: You separate the two of them, why? What do you expect?

Teacher: I want her to say: 'but, the two others, then, and the two others, but look: here's one that goes with this one!'

The teacher used a highlighter to mark up relevant information. By highlighting the model dimensions, she drew the pupils' attention to essential data. But she also wanted the pupils to detect a relationship between a scale drawing and an actual object. According to her, understanding this relationship should have helped them realize that the length and width of the two models were of the same measurement domain, and that the non-highlighted numbers represented scale factors (1:45 and 1:20). She wanted the pupils to establish a relationship between the two scales and their respective groups of measurement data. Her preoccupations were: (a) *to help the pupils from Charlotte's group find the right equation*, (b) *to help the pupils from Charlotte's group to see the relevant relationship between the numbers*, and (c) *to keep the pupils involved in a given task.*

The teacher was interrupted by Charlotte and Gerald, each of whom came up with a solution. First, Gerald suggested multiplying the length of the model by its width, thus getting what he erroneously named "perimeter" (in fact, the surface area). Gerald seemed to have interpreted the act of highlighting two pairs of numbers (3.2 and 9 and 22 and 7) as an evidence of a relationship between the two numbers of each set, and not as an indication of a link between a set of two numbers and a corresponding scale. So, he simply chose to multiply the two numbers of each set. Gerald's suggestion was perceived by the teacher as wrong, and her preoccupation was: *to invalidate Gerald's suggestion.*

Table 4. Verbalizations in the classroom and the self-confrontation interview (Minutes 55-56)

Classroom verbalizations	**Video and Behaviours descriptions**	**Self-confrontation verbalizations**
Gerald: So, there, in fact, we did 3.2 times 9 and get 28.8. Teacher: Why did you do 3.2 times 9? Gerald: Because that's the width and that's the length.	Gerald speaks to the teacher ; Charlotte, in-knee on her chair, looks at the teacher Gerald points to the	Researcher: So, when he says that… what do you say? Teacher: I say to myself: but he hasn't understood yet, because in my mind, there is this plan that I am waiting

Teacher: And what does that mean, when you've done this?

Charlotte: Oh no! Teacher! I've found it!
That!

Gerald: (At the same time) Well, the perimeter, and after we're going to do 22 times 7!

Teacher: You're going too fast, Gerald, you're panicking! Calm down!

Gerald: 22 times 7, and here we get 28.8 for 3.2 times 9, here, so we'll get …

Teacher: What will you get with that? Explain it to me, you…

Gerald: The perimeter!

Teacher: The perimeter?

Gerald: Yes, of the car, of course…

Teacher: The perimeter!

Charlotte: Teacher, I understood!

Gerald : Yes… but no, but…And then we'll do 22 times 7, we'll get the result and we'll do 3.2 times 9… 28.8 so, look, and then we will do a …

Charlotte: Teacher …

numbers on the problem sheet.

Charlotte hits on the table, then points out the text of the problem with her pen.

Charlotte looks at the teacher

Gerald points out alternately the numbers in the problem sheet and in his copybook

The teacher is staring at Gerald for an instant

The teacher turns to

for. And it's true that I didn't consider that there might be others, and then, when he said: "we only need to multiply this by this and it gives that", I say to myself: OK, he says he has understood, but that's not what I expected! […]

Teacher: On top of that, he's talking about the perimeter, and I say to myself, he's talking to me about the perimeter—but he's going to work out the area, yes... OK: he's really... lost it!

Teacher : When he talked about the perimeter, I said to myself : OK, he hasn't understood… and that's precisely it, because there is some vocabulary which is for me, well... when he's talking to me, for me it's revealing… There we are, I say to myself, he's talking about the perimeter, he hasn't understood anything!

Researcher: You've understood, but you stop him….

Teacher : Oh yes, I get it …	Gregory ; Gerald leans over his copybook ; Charlotte looks at the teacher	Teacher: Yes, I understood what he wanted to say, but I stop him because for me, its' not the right plan!

The teacher invalidated Gerald's suggestion in three stages: (a) she asked him to explain the equation, (b) she expected him to "talk about the surface area" of the model, while Gerald insisted on using the term "perimeter", and (c) she asked him about his use of this word. For her, Gerald's second mistake was to talk about perimeter instead of area. She expected him to correct his error, which seemed to her to reveal a wider lack of understanding of the situation. She asked him to explain his reasoning, leaving alone the wrong use of terminology. As soon as she realized that Gerald's explanation was not getting him closer to the right answer she briskly interrupted him. Her preoccupations during this exchange were: (a) *to have Gerald explain his reasoning,* and (b) *to invalidate Gerald's suggestion*.

Charlotte's suggestion started at the same moment as Gerald's. The teacher let Charlotte talk after having listened to Gerald. Charlotte used her pen to successively point to relevant pairs of numbers, indicating the model measurements and the scales. She pointed to number 9, then to the scale 1:45, then to number 3.2, and again to 1:45. She did the same for the other model, indicating 22 and 1:20, and then 7 and 1:20. Charlotte emphasized her actions with deictics (repetition of "*that and that"*).

The validation of Charlotte's suggestion was direct. The following conversation shows how the teacher was interpreting the solution offered by Charlotte while confirming it at the same time (see Table 5). The text of the problem mediated the two protagonists' actions because it was physically at the centre of the interaction. A sequence of gestures accompanying Charlotte's explanation, coupled with her discourse, was interpreted by the teacher as a sign of comprehension of the scale ratio multiplicative nature. She assumed that Charlotte had realized that to make a scale model bigger, she had to perform multiplication. The teacher therefore did not insist that Charlotte demonstrate her equation. Her preoccupation in that case was *to validate Charlotte's suggestion.*

Table 5. Classroom and self-confrontation verbalizations (Minute 57)

Classroom verbalizations	**Video and Behaviours description**	**Self-confrontation verbalizations**
Charlotte: Look, Teacher, I think I got it! Teacher: Wait a moment… Charlotte: The length is 9 cm. Teacher: Yes! Charlotte: So, this at least … Teacher: The length is 9 cm, so? Charlotte: So, here… Teacher: Yes! Charlotte: We have to do… Teacher: Yes! Charlotte: That and that… Teacher: Yes! Charlotte: And after… Teacher: Yes! Charlotte: We have to do… Teacher: Yes! Charlotte: And that… Teacher: Yes! Charlotte: And after, we will do… Teacher: Yes! Charlotte: That and that… Teacher: Yes!	Charlotte points out the numbers in the problem sheet. The teacher approves with a bow of her head Gerald writes, leans over his copybook, then raises his hand.  The teacher nods her head. Charlotte points out the numbers in the text of the problem. At each ‘yes’, the teacher nods her head. Gerald looks at that Charlotte is pointing out	Researcher: Yes, yes … and when she says: ‘we’re going to do’, what is your interpretation of it? Teacher: Multiply! Researcher: Multiply? Teacher : Yes … Researcher: Why? Teacher: I don’t know. Researcher: You don’t know… For you, it’s obvious that you have to multiply? Teacher: Yes, because it should be bigger. Researcher: So, you think that she has understood that it should be bigger? Teacher: Yes, I think that she has understood that it should be bigger, but… Researcher: But you don’t ask yourself the question... When she says “that and that”? Teacher: No, in fact… Researcher: For you, that means multiplication? Teacher: Well, we multiply

Charlotte: And that… Teacher: Yes! Charlotte: And that... Teacher: And yes! Gerald: teacher, I don’t mean that!	that and that, we have to “do”… Researcher: She said “do”, she didn’t say “multiply”? Teacher: Mm… But in fact, when she showed me the numbers, when she made those gestures “that and that”, I said yes! Researcher: What does it mean, that? Teacher: That there is a relationship between the two!

Pupils’ individual actions. Between the 20th and 25th minute, Charlotte, Gerald, Justine and Gregory came up with some ideas (Table 6). Gerald, Justine and Gregory suggested division. Charlotte thought that the problem contained a “trick” and assumed that she had found it. Gerald quickly abandoned his suggestion to divide, which was ignored by the teacher.

Together with Justine, he interpreted the measurements totally ignoring the notion of scale, and decided that the biggest “real car” would be the one corresponding to the model with bigger dimensions. Justine’s, Charlotte’s and Gerald’s preoccupations at that moment were: (a) *to suggest division as a possible way to solution*, (b) *to obtain validation*, (c) *to facilitate the task*, and (d) *to make a good impression*. Four pupils in the group assumed that math operations were required to solve the problem. Gerald, Justine and Gregory suggested division, Charlotte a sum. Charlotte’s preoccupations were: (a) *to find a hidden trick, and* (b) *to make a good impression*.

Table 6. Classroom verbalizations (Minutes 20 to 25)

Classroom verbalizations	**Video and Behaviours description**
Justine: Teacher, I think I’ve found something.	The teacher leans over the four pupils.

Gerald: 22 divided by 7.

Justine: For the…22 divided by 7.

Gregory: 3 leaves 1. Yes: 3 times 7 is 21, leaves 1.

Charlotte: I’ve found a trick! I’ve found a trick!

Teacher: So…

Charlotte: I’ve found the trick, Teacher!

Teacher: Why do you believe there’s a trick, Charlotte?

Charlotte: Well, because there, it makes 1/20….

Teacher: Yes…

Charlotte: And that there, 1/40.

Teacher: 45, yes…

Charlotte: 45…

Teacher: Yes.

Gerald: Ah, I think I’ve got it, Teacher!

Charlotte: And, since it’s not the same number, it can’t be that this one bigger because already there, it’s 2 cm and there it’s 7 cm. So, you need to add something and it’ll increase the number…

Gerald: Teacher, I think I’ve got it!

Teacher: You believed right from the start that the two cars are not the same?

Justine: Well, no, no. This one is smaller because 9 cm and 3.2 cm. And that this one is 22 and 7 cm.

Charlotte: So if you add this and that it will give a result. And there is something we have to add here. But I don’t know what…

Gerald: No. Otherwise, Teacher, we should do a 40, a 45, divided by 20…

Charlotte: No, but that’s not what I mean. It’s just that, there is…It looks like there, it’s this one

She listens to their suggestions.

Gerald looks in turn at the teacher, Justine, Gregory and Charlotte while they are speaking. Charlotte leans towards the teacher, and, smiling, talks to her.

Charlotte points out the scales in the text of the problem.

Gerald turns to the teacher and raises his hand before speaking to her.

Charlotte looks at the teacher, waiting. Gerald turns again to the teacher, raises his hand before speaking.

Justine points out the text of the problem with her finger. The teacher listens and then leans over Charlotte.

Gerald takes advantage of a brief moment of silence to speak up.

that's going to win. Because if you add things on to this, it'll give a big result and we'll drop this one…

Teacher: And what makes you say that it will give a big result?

Charlotte: I don't know, I don't know: that's the way it is!

Justine indicated that 1 cm on the model corresponded to 45 cm of the actual car surface. She came close to the expected solution. She unsuccessfully tried to explain to the teacher (minute 35) that the ratio 1: 45 could be added as many times as necessary. She suggested a solution which involved adding the number that corresponded to 1 cm on the scale. The teacher did not understand Justine's reasoning and thus did not realize that she had almost found a solution. In this situation, Justine's preoccupations are the following: (a) *to use an iterative addition method to solve a problem* and (b) *to obtain a positive validation*.

In the 54th minute, after the teacher had highlighted important numbers, Gerald immediately suggested a solution. He kept searching for a solution despite the teacher's repetitive demands for explanation and her rejections of his answers. His preoccupations were: (a) *to suggest a solution which involved calculating the perimeter* and (b) *to obtain positive validation*.

Charlotte then implicitly indicated her solution. She pointed to the numbers on the problem sheet, accompanying her gestures with successive deictics ("*that and that*"). She was careful about indicating the numbers to be used in an equation and did not provide an equation that expressed the relationship between these numbers. She assumed that her explanation was sufficient for the teacher. Her preoccupations were: (a) *to offer a solution based on multiplication* and (b) *to obtain positive validation*.

The configuration of activity

The configuration of activity can be described from the individual action of the teacher and pupils. This section discusses the three dimensions of the configuration of activity: a process that emerges from (a) the coupling of individual actions and (b) the points of articulation meaningful to the agents; and (c) a process that creates balance and emerging order.

Pupils' inquiry and its coupling with the teacher's action.

The analysis of the pupils' courses-of-action demonstrates their attempts to find a solution to the problem. In their search, they proceeded with a pragmatic inquiry (Dewey 1938/1963) whose progress was slow and complex; they used all available clues, considering and abandoning many leads and, exploring until they found the solution.

At first, they thought that the answer was contained in the text. They assumed that a bigger "real car" would be the one with bigger measurements. They knew that some problems could contain traps: Charlotte tried to figure out a possible trap. When Charlotte and Gerald's first suggestions were rejected by the teacher, the pupils continued their search for (a) the correct equation and (b) the right numbers to use. They suggested addition, division and multiplication, manipulating the numbers in different ways. It should be noted that the problem was composed by the teacher which led to her setting up her own expectation structure (to work out the problem, one needs to multiply the dimensions of each model by its respective scale and then compare the results). This expectation structure led her to invalidate any proposals that did not rely on multiplication, as not conforming to her expectations.

The students finally thought of multiplication: their proposals of addition had been invalidated (minutes 24, 34), as well as those of division (minutes 20, 35, 38). From minute 38 on, all the proposals were exclusively about multiplication. They then looked for the numbers to multiply. The hints given by the teacher were aimed at bringing them to successive multiplications (minute 42). Two students wanted to multiply 45 by 2. But this idea was not accepted, and the students did not grasp that 45 needed to be multiplied by 9 and then by 3.2.

In the 54th minute, Gerald came up with a solution: he suggested multiplying numbers to calculate what he called the "perimeter". He made an equation using the highlighted numbers. He realized that the nature of the model measurements (length and width) and their spatial grouping were *affordances* (Gibson, 1979; Norman, 1993), that is, the available resources. These measurements reminded him of another classroom work that involved finding the perimeter and area of polygons. Unfortunately, he confused the two notions.

Finally, Charlotte suggested her solution: she pointed to the numbers she was using two by two. She did not demonstrate the equation because she assumed that her reasoning was obvious to the teacher.

The pupils' proposals were made on the basis of diverse clues in association with the teacher's actions, the actions of their classmates, and some elements found in the text as clues: teacher's validations or invalidations and explanations, her mimics and solutions offered by the pupils from the same group and from other groups, and the location of the numbers in the text. Gerald's suggestion (minute 54) was consistent with both the clues collected during the inquiry (one has to multiply) and with his school culture ("something" can be calculated using the length and width of a polygon). Charlotte's suggestion was also consistent: she did not demonstrate her equation because she assumed that the solution was obvious to the teacher. The protagonists had collectively come to conclusion that in order to solve the problem, one had to multiply. All that she had to do was to correctly indicate the numbers that had to be multiplied. Charlotte's suggestion was also supported by a topological clue: the symmetrical organization of the data on the problem sheet was an *affordance* for her, indicating the relation between the measurements and the scales.

The configuration of mathematics inquiry activity

The configuration of activity emerges from the points of articulation between individual actions of teacher and pupils. Individual actions are made possible in return by these points of articulation. This concept accounts for the dynamic character of situational constraints which link the teacher and pupils by multiple "reciprocal dependencies" and thus contribute to forming a collective. They thus allow for the emergence of the form which inversely makes them possible. Articulation points are the situational constraints that are meaningful to the teacher and pupils: (a) the nature of the pupils' work, (b) its spatiotemporal organization, (c) the presence and functioning of artefacts, and (d) the types of interaction between agents. These constraints are only meaningful to certain agents, and even then, the meaning is attributed according to a personal and partial interpretation: what is meaningful in the problem at a given moment to one pupil is not necessarily meaningful to the others at the same moment. These constraints nevertheless play an essential role as they contribute to the emergence, balance, and maintenance of the configuration in the classroom. Mathematical problem-solving requires that the pupils conduct an inquiry to diminish the level of uncertainty of the situation which is initially confusing and unpredictable. This motivates them to search for clues, to suggest various hypotheses and to construct guaranteed assertions (Dewey, 1938/1963) until the solution is found.

The spatiotemporal organization of the classroom and the nature of the pupils' work render possible both cooperation and competition. This organization is situated in the school culture (Gallego, Cole, & The Laboratory of Comparative Human Cognition, 2001): the organization of groups is linked to the ideas of "constructivist pedagogy" that are frequently evoked in teachers' training centres. Their inquiry is simultaneously cooperative and competitive (Rognin, Salembier & Zouinar, 2000) within each group and between groups. According to these authors, the agents cooperate when they are engaged side by side in verbal or non-verbal interactions, when their actions are coordinated and synchronized, and when the aims they pursue are equally coordinated. The articulation between the preoccupations of helping and accomplishing classroom work contributes to the production of mutual intelligibility and shared understanding, the characteristics of cooperative activity (Rognin, Salembier & Zouinar, 2000) that help to regulate coordination between agents. Improvised and informal processes – of validation, the institution of actions, inquiry – take over from mechanisms of adaptation and self-organization. This allows the protagonists to coordinate to accomplish tasks related to problem-solving or text reading. The suggestions made out loud by pupils from one group, followed by the teachers' validation or invalidation, are taken into account by pupils from other groups. The pupils' search for solutions is re-directed by their need for validation. The suggestions are similar to probes sent toward the teacher to collect clues. They enable the pupils to progressively diminish the complexity of the problem and to eliminate hypotheses.

Moreover, when one group tries to draw the teacher's attention as she moves around, suggestions come not from the group but from competing individuals: each pupil is trying to create a positive image of him- or herself. This competitive urge prevents them from putting their suggestions and findings in writing, and solutions are thus never sufficiently developed for the students to arrive at true "problem-solving". These proposals cannot be validated by the students themselves

The artefacts used in this configuration have cognitive functions. They structure individual action and the articulation of individual actions (Norman, 1993). The teacher's help is structured by the word problem, in particular by the expectation structure she has developed. This idea corresponds to the problem- solving pedagogy, advocated by the French Department of National Education. Moreover, the choice of complex numerical data (measures and scales) prevents younger pupils from making mental equations. By asking for a comparison of the two vehicles requires comparing two sets of data (4 measures and 2 scales), making it more difficult to establish a correct relationship between numbers.

The teacher-pupil's interaction, characterized by the pupils' requests for validation, and the validations–invalidations of the teacher, narrows down the field of possibilities for the pupils' inquiry. When the pupils make their suggestions, validation is more or less explicitly requested. These requests facilitate their task, helping them to avoid wasted time on dead ends. The suggestions flow in quick succession due to the pupils' competitive preoccupations and to their interpretations of the teacher's reactions to their suggestions. Validations and invalidations of pupils' suggestions are given frequently. Their frequency avoids dead time, refocusing pupils' individual actions, and helping them avoid wrong leads. The frequency of help also allows maintaining pupils' involvement in their schoolwork.

The inquiry in mathematics: a balanced configuration of activity.

This configuration of activity presents a state of balance established between tensions. Tensions are provoked by (a) convergence – divergence of agents' preoccupations and (b) the constraints linked to the points of articulation in the configuration of activity. These two types of tension are closely articulated because constraints modify the agents' goals by opening and closing possibilities for action.

Pupils' preoccupations with obtaining validations, making a good impression, or facilitating the task are articulated with the teacher's preoccupation with keeping them involved in a given task. These preoccupations are somewhat divergent: while the teacher expects the pupils to be involved in a problem-solving task, stimulated by the need for the right solution, the pupils expect the teacher's immediate validation, approval, or an easier way to find the solution. However, these expectations transform into actions which, for the teacher, manifest the pupils' involvement. At the same time, the teacher's preoccupations with helping pupils and pupils' preoccupations with finding the solution are largely convergent: they correspond to similar expectations, linked to the search for a correct answer. In spite of the profound divergence between some of the preoccupations and expectations of the agents, a state of balance is achieved and the configuration becomes viable.

Moreover, certain tensions in this configuration of activity are linked to points of articulation and, in particular, to the use of a word problem and the forms of interaction in the classroom. The teacher's choices during the conception of this problem caused substantial difficulties for the pupils. They considered a large number of calculations and relations between the numbers. This explains the long duration of their inquiry (85 min.), a high number of incorrect answers, the recurring moments of discouragement, and the teacher's need to constantly sustain their involvement. However, this involvement did remain high, and an hour later the pupils were still searching actively and suggesting solutions. At the same time, the problem itself became a factor of tension balance, mediating the pupil's inquiry and the teacher's help.

The forms of interaction contribute to the balance of the configuration. They are characterized by the opening of interaction windows (Gal-Petitfaux, 2003) that provide possibilities for individual action. They contribute to the validation – invalidation of suggestions: when the teacher opens an interaction window with Charlotte (minute 20), putting aside the suggestions of other pupils (Justine, Gerald and Gregory), they perceive it as an implicit rejection of their suggestions. Moreover, when the teacher interacts with one of the pupils, the opening of this interaction window allows the others to develop various preoccupations of searching for the solution, but also those of distraction. There is no doubt that these forms of interaction are also supported by the constructivist pedagogy taught in teachers' training centres. This pedagogical approach insists that the pupils have to "all learn by themselves" and to "construct their knowledge". And finally, these forms of interaction allow for the conduct of the inquiry and for the problem solving. In mathematics, they help achieve the state of relatively comfortable balance for the actors, enabling pupils to solve problems and the teachers to keep them involved in a given task..

Formalization of the notion of configuration of activity

Although configurations of activity were studied during a mathematics lesson in primary school, they concern all types of social activities. We can observe their emergence in the classroom during different lessons, on the field in team sports (Elias, 1966), in orchestras, offices, workshops, restaurants, etc.

In the classroom, configurations are limited in time by the teacher's and pupils' individual actions and by the articulation of these actions. Therefore, even when the teacher instructs the pupils to start working, it may be not sufficient: the pupils need to become deeply involved in the task. In the classroom space or in specialized rooms, configurations are limited by the phenomenal capabilities of the agents: they cannot see through the classroom walls or hear farther than a few meters. These are shared situations (Durand Saury & Sève, 2006), simultaneously experienced and given by the sensorial, perceptive and cognitive capacities of the agents.

Although configurations are emergent forms, they may be embedded in both the professional culture of teachers and the academic culture of pupils; in turn, their viability (i.e. their stability-in-time associated with the possibility for both teacher and pupils to satisfy their intentions) constitutes to and perpetuates these cultures. Their stability can also be explained by limitations of the teacher's intervention: configuration allows the teacher to conciliate multiple and contradictory constraints in a multidimensional and very complex task, as Doyle showed (1986), and we can hypothesize that the classroom configurations stability is linked to this aspect of teachers' work.

The emergent properties of configurations are not incompatible with the fact that the most viable configurations become components of the school culture (Gallego & al., 2001) which are inscribed in teachers and pupils' culture. These components of a local culture are "near at hand" every time the agent wants to act in a particular context. This cultural inscription allows configurations to self-perpetuate in time and space through the intermediation of agents' memory and the artefacts that transport them (Lemke, 2000): a blackboard, a ruler, the desk arrangement — they all contribute to the emergence of identical configurations of activity in different places and at different moments.

The agents have only slight and partial consciousness of these configurations, and the configurations do not result essentially from the agents' conscious "determinations" (to form work groups, to find a solution, etc.). But determinations, as well as knowledge (of the problems of proportionality, etc.) and culture of both pupils (solving problems, finding the calculations that need to be made, etc.) and teachers (ways of organizing work, assigning tasks to pupils, etc.) (Gallego & al., 2001) form the material from which the collective activity is configured. "Determinations", knowledge and culture contribute to the configurations that characterize an academic subject, a school grade, and even the school in general.

Configurations of activity concern educational tasks, some of which are very old, like collective oral reading or problem-solving. For example, configurations of the "taking turns" type are found in many school subjects. They persist in time and, when needed, are reactivated by teachers who create certain conditions for their emergence. They are transported by artefacts (the blackboard, problem sheets, textbooks, etc.) that ensure their semiotic function: artefacts are the memory of past actions and the support for rules of action and the typical way of doing things in school. In the history of education, for example, configurations can be transformed by modifications of artefacts (textbooks) or the classroom space and by the slow evolution of norms and regulations in the classroom.

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